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Research Article

Assessment of *Cinnamomum tamala* (Tejpat) Plantation in Community Forests: A Case Study from Tanahun District

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Cinnamomum tamala is the major NTFPS cultivated commercially in major parts of Nepal. A research was conducted on the plantation of *C. tamala* in three research sites, Malayang community forest (CF), Saldada CF, and Banaskhadi CF, of Tanahun district for calculating the survival rate, mortality rate, and overall plant growth performance. Simple stratified random sampling methods were used; height and mean breast diameter (DBH) were measured, and a prestructured questionnaire was used for collecting the data and information from the research sites; also, secondary data from AFO, Tanahun, were used for the analysis of data. The first-year survival rate was the highest (62%) at Saldada CF and lowest at Banaskhadi CF (35%); however, the second-year survival rate was the highest at Saldada CF at 50%. Mean height : DBH (cm) of the plant was the highest at Saldada CF (126 cm) and lowest at Banaskhadi (25 cm). The Pearson correlation analysis at $\alpha = 0.05$ was conducted to test the association between mean height and DBH (cm) of *C. tamala* which was $r = 0.93$, df = 12, $p < 0.001$, $r = 0.30$, df = 11, $p < 0.001$, and $r = 0.88$, df = 11, $p < 0.001$, respectively, of Saldada CF, Banaskhadi CF, and Malayang CF. The mean height and mean breast diameter (DBH) (cm) of *C. tamala* were highly correlated in Saldada CF with the highest second-year survival rate. As *C. tamala* grows well in acidic soil, pH of all the three research sites was basic, more than 7.5; however, Saldada CF had the highest growth rate than others because the organic matter content was the highest (3.4).

1. Introduction

Cinnamomum tamala, known as tejpat native to Southeast Asia, is an evergreen tree which belongs to the Lauraceae family that can grow about 1–20 m tall and be 20 cm in diameter [1]. It can grow up to 20 m tall in the forests and farmlands in the Middle Hill Range of Nepal between 450 and 2100 meters above sea level (masl) and is commercially cultivated in Udaypur and Palpa districts and is cultivated well in southwest-facing landscape [2, 3]. *Cinnamomum* plant can produce 10–20 kg dry leaves, and 0.2–0.4% oil can be extracted from leaves [4, 5]. *C. tamala* is a much used species of medicinal and aromatic plants (MAP), found in the wild as well as being cultivated by mountain farmers which helps to meets the requirements of mountain-specific products to enter national, regional, and global value chains [5, 6]. Also, children having cough or dysentery can be cured with its seeds ingested with honey or sugar [5, 7]. Since the early age, *C. tamala* is used as spice (in local and regional culinary), food, flavour, and pharmaceutical and for the production of essential oils (potential for local value addition also) [4, 6].

Height : diameter ratio, being an individual tree-based index, is calculated by dividing the height of the crop tree by the diameter [8]. The relationship between tree diameter at breast height and tree height is the most commonly used measurement of the tree size [9]. Site factor, climatic factor, and other conditions affect the height-diameter profile, survival, and mortality rate of every plant species and also plants of the same species, so the site and its condition must be known before plantation [10, 11]. Soil pH can affect the availability of nutrients and activity of many essential

microorganisms [12]; the soil roughly contains 50–60% of mineral matter, 20–35% of water, 15–25% of air, and little percentage of organic matter.

Every year, a huge amount of budget is spent for seedling development and plantation; however, all the efforts for the establishment of plantation become unsuccessful due to the lack of assessment of survival and huge mortality within the plantation site of seedlings [13]. Although few studies have been performed for the survival rate and growth performance of *C. tamala* in Nepal, scientific study of their survival rate, mortality, and growth performance on various soil types was not performed before. To overcome these limitations, a study was carried out for the status of *C. tamala* by assessing the survival rate, mortality rate, and growth performance on Tanahun districts in Saldada community forest (CF), Malayang CF, and Banaskhadi CF of Myagde Rular Municipality.

2. Method and Methodology

2.1. Study Site. The study was carried out at Saldada CF, Banaskhadi CF, and Malayang CF which were established in 2018 and 2019 (2^{nd} and 1^{st} year of plantation), respectively, and at Myagde Rular Municipality, Tanahun district (Table 1). The latitude and longitude of the research area were $27^{\circ}\,54'\,59.99''$ N and $84^{\circ}\,14'\,60.00''$ E, respectively (Figure 1).

2.2. Survival Rate and Cause of Mortality. Survival percentage was calculated by simple formulae, calculating the total plant survived in the 2.5 m^2 area and calculating the total number of plants planted in the same area.

Survival percentage = (total plants survived in the research area/total plants planted) $*$ 100%.

A semistructured questionnaire was used for the user's groups and farmers for 106 households involved in the plantation to obtain information from respondents about the cause in the research site.

2.3. Measuring the Growth Stage. For assessing the growth stage of the *C. tamala* plant, the following parameters were compared with the values/data taken during the plantation year:

(i) Height of the plant (cm): height of the plant was taken from the ground surface to the top of the plant with the help of a tape and bamboo stick

(ii) Collar diameter of the plant (cm): collar diameter of the plant was taken at 10 cm from the soil surface with the help of a tape or rope

(iii) Height: collar diameter ratio: the mean value of height and diameter of each site was calculated

2.4. Soil Data. The soil sample at depth 0–15 cm was collected from the centre of each plot by means of a metal soil corer of 4 cm diameter and placed in a labelled sample bag. The collected sample was brought to the laboratory to determine the organic matter and soil pH. The soil organic matter in the laboratory was determined by the colorimetric determination of soil organic matter process.

2.5. Methods of Data Analysis. All the collected data were entered in MS Excel version 19, and data analysis was performed with the help of MS Excel and RStudio. Correlation analysis was computed by using RStudio. Graphs and bar diagram were generated from MS Excel. Analysis of variance (ANOVA) was computed with the help of RStudio.

3. Results and Discussion

3.1. Survival Rate. Saldada CF research site is located on the slope at the southern-western aspect having higher survival rate of 62% among all the three sites, compared to Banaskhadi CF which was at the southern-eastern aspect and with abundance of slate mine on the past, having lowest survival rate with 35% in their first year of plantation (Figure 2(a)), whereas Malayang CF and Saldada CF were at their second year of plantation stage; second-year survival rate was found to be 50.80% higher than that of Malayang CF which has both southern-eastern and northern aspects of the plantation (Figure 2(b)).

It was found that the Saldada CF research site was favoured by its aspects. The first-year survival rate of *Cinnamomum* at Saldada CF was found to be 62% which is similar to the finding of Paudel and Acharya [13], where the first-year survival rate of Cinnamomum was 60%; however, it has vast difference with Banaskhadi CF. Cryptocarya is found to be favoured by shade trees in the early stage of growing most of Cryptocarya plant have died during the dry period; the poor performance was due to photoinhibition which was reported by Erskine et al. [11]; similar things were taken into consideration for Banaskhadi CF where no shade trees were planted on the field. Also, Tanahun district NTFPs' book published by DFO, Tanahun, reported that growth of *Cinnamomum* is favoured by shade up to the age of 4-5 years [2]; this indicates that the aspect and shade tree need to be considered during the site selection for the plantation of *C. tamala* in the area.

3.2. Mean Height vs. DBH. Though the three research sites were at different locations and altitude, they have almost similar habitat and weather conditions. Among two sites, Saldada CF and Malayang CF, which were at their second year of plantation, the highest growth performance of the plant was found at the Saldada CF site, recording the tallest height of the seedling to be 126.6 cm and smallest height of the seedling to be 51 cm, whereas tallest height of the 2nd-year plant of Banaskhadi CF was 88.75 cm tallest among and smallest to be 56 cm, (Figure 3). Very small increase in height with the increase in diameter was observed from all three research sites. Banaskhadi CF site has seedling of 1^{st}-year plantation, the tallest seedling was recorded to be 26.33 cm height and smallest height to be 23 cm. (Figures 3 and 4).

The mean height : diameter ratio of the Banaskhadi CF is was lowest because of the first year of plantation as plants had no growth and developed properly, whereas the height : diameter ratio of the Saldada CF and Malayang CF has highest because the seedling are on the second year of the plantation (Figures 2(a), 2(b), and 4) [3, 9].

Table 1: Study area and details of the three community forests.

Name of CFUG	Saldada CF	Malayang CF	Banaskhadi CF
Geographic region	Midhill	Midhill	Midhill
Rular Municipality	Myagde-5	Myagde-5	Myagde-5
Management practice	Community	Community	Community
Area of plantation (hectare)	3.2	5.6	3.8
Forest type	Natural	Natural	Natural
Year of plantation	2018, June	2018, June	2019, June

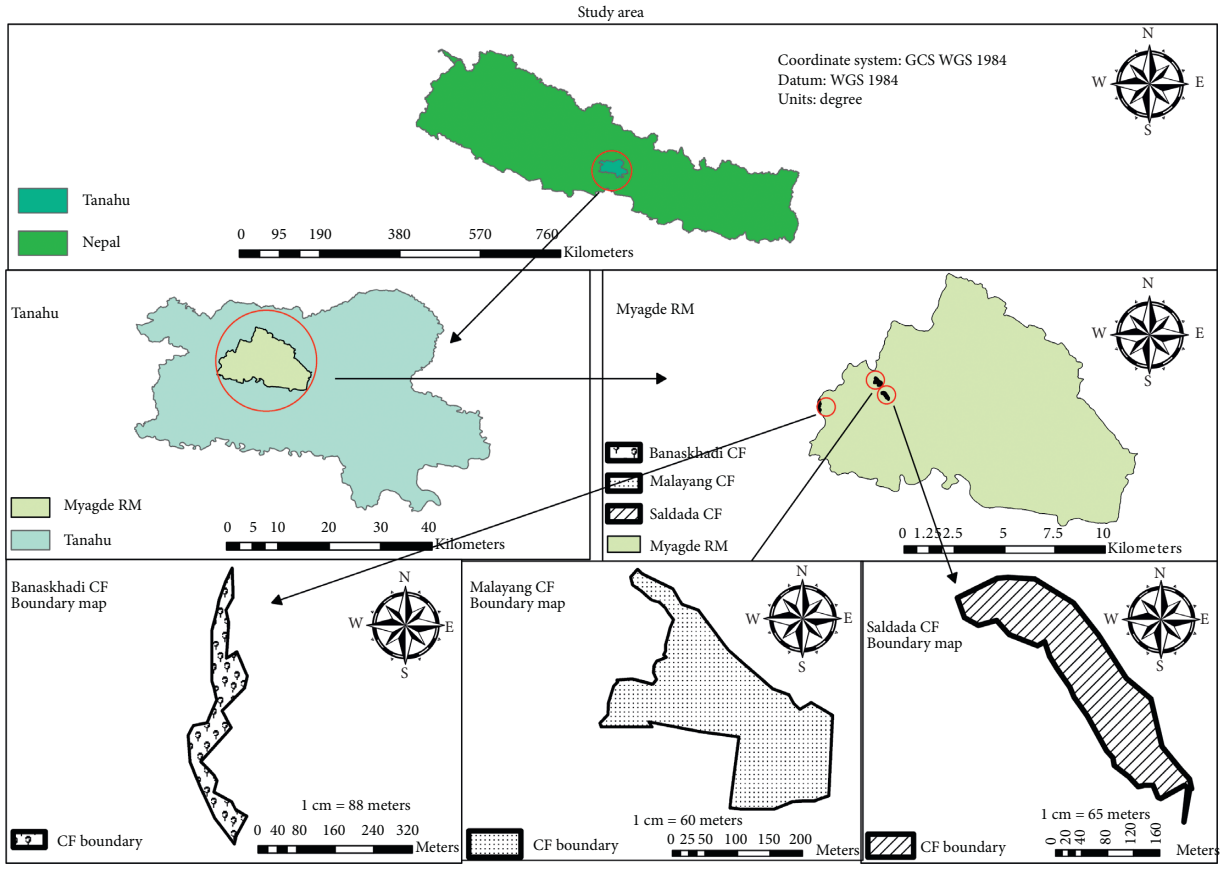

Figure 1: The three different study areas of the research.

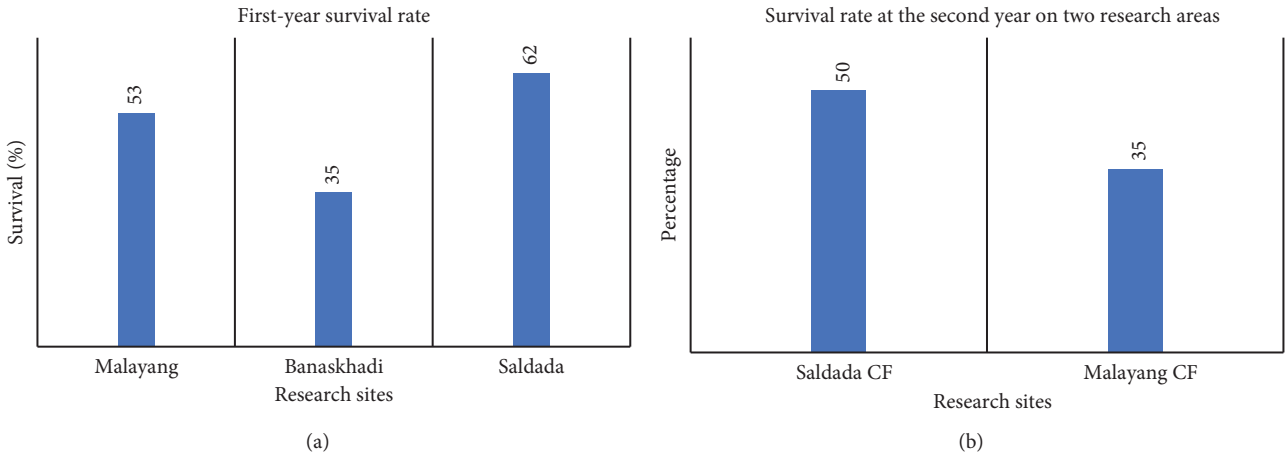

Figure 2: (a) First-year survival rate and (b) second-year survival rate of *C tamala* on three community forests.

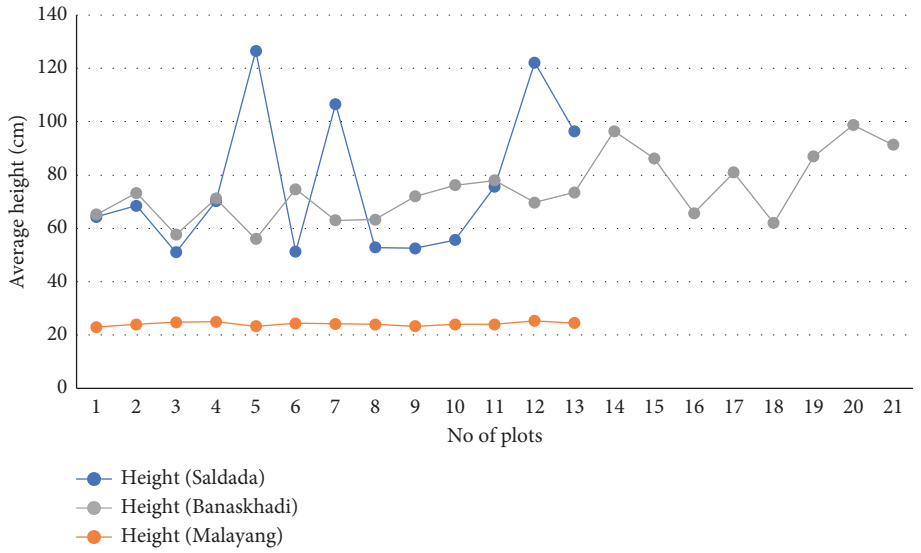

Figure 3: The average height of plants on three different research sites.

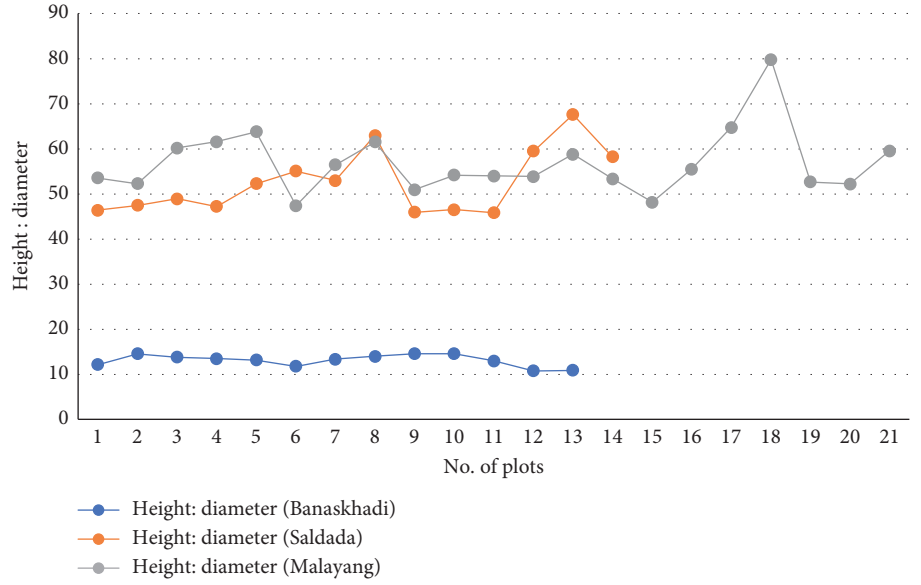

Figure 4: The height : diamater ratio of the plants on three research sites.

A linear increase in both diameter and height of the tree was found in most of vigorously growing trees, and trees with declining diameter growth rate exhibited asymptotic toward height growth [9].

3.3. Result and Discussion of Soil pH and Organic Matter

3.3.1. Soil pH. pH of 2 sites, Malayang CF and Banaskhadi CF, was found to be neutral with range 7.4 and 7.5, whereas pH of Saldada CF was found to be alkaline with pH 7.6. The organic matter content of Saldada CF and Malayang CF was found to be medium among which Saldada CF had the maximum amount of OM (3.31), and Malayang CF had 3.17, whereas the organic matter content of Banaskhadi CF was found to be low with 2.4. Saldada CF had the maximum amount of OM among all the three sites (Table 2).

Soil pH plays a vital role in plant growth and its production. Imbalance soil pH or pH range of soil that does not fit the plant can lead to the failure of plantation. According to the DPR [2], soil pH at the range of 4 to 5.5 (acidic pH) is best for the growth of *Cinnamomum* [10, 12]. From the lab test report, none of the sites have acidic soil pH which can be the major cause of the failure of plantation. Alkaline soil pH could be one of the reasons for low survival rate. OM content of all the three sites was found to be low as needed by

Table 2: pH and percentage of the organic matter content of the soil in three research sites.

S. no.	Community forest name	pH	OM (%)
1	Saldada CF	7.6 (alkaline)	3.42 (medium)
2	Saldada CF	7.6 (alkaline)	3.20 (medium)
3	Banaskhadi CF	7.5 (neutral)	2.59 (medium)
4	Banaskhadi CF	7.5 (neutral)	2.32 (low)
5	Malayang CF	7.4 (neutral)	3.32 (medium)
6	Malayang CF	7.3 (neutral)	3.038 (medium)

pH; >IF > 7.5, "Alkaline," IF > 6.4, "Neutral," "Acidic."
OM: =IF > 5, "High," IF > 2.4, "Medium," "Low."
N : IF > 0.2, "High," IF > 0.1, "Medium," "Low."
P2O5 : IF > 55, "High,">31, "Medium," "Low."
K2O : IF > 280, "High," IF > 110, "Medium," "Low").
Note: soil OM was determined by the colorimetric determination of soil organic matter process.

C. tamala for its growth. *C. tamala* thrives well in soil with the high amount of OM [2, 12, 14]. Less amount of OM could also be the reason for low survival rate in Banaskhadi CF and Malayang CF in comparison with Saldada CF which had a bit more OM content than the other two CFs.

3.4. Statistical Analysis. A parametric correlation (Pearson) ($\alpha = 0.05$) was performed to test the association between mean height and mean breast diameter (DBH) (cm) of *C. tamala*. A significant correlation was found between the mean height and mean breast diameter (DBH) (cm) of *C. tamala* of Banskhadi CF at $r = 0.54$, df = 11, and $p < 0.001$.

There was a significant linear relationship between mean height and mean breast diameter (DBH) (cm) of *C. tamala* of Banaskhadi CF ($R^2 = 0.30$, $F_{(1,\ 11)} = 68.4$, $p > 0.001$). A parametric correlation (Pearson) ($\alpha = 0.05$) was performed to test the association between mean height and mean breast diameter (DBH) (cm) of *C. tamala*. A significant correlation was found between the mean height and mean breast diameter (DBH) (cm) of *C. tamala* of Saldada CF at $r = 0.93$, df = 12, and $p < 0.001$. There was a significant linear relationship between mean height and mean breast diameter (DBH) (cm) of *C. tamala* of Malayang CF ($R^2 = 0.88$, $F_{(1,\ 12)} = 88.1$, $p > 0.001$).

There was a positive correlation between mean height and mean steam diameter (DBH) of *C. tamala* on two community forests, Banaskhadi CF and Saldada CF, 0.54 and 0.93, respectively. And the higher second-year survival rate of the plants shows the positive relation site specific, so we can draw the conclusion that seedlings were well adapted to the environment and performed well. *Cryptocarya erythroxylon* and *C. tamala* are plants that fall under the same family. Height of *Cryptocarya erythroxylon* was found to increase in between 10 and 30 cm in the first year and around 80–100 cm in the second year. The result of this study shows the similar growth performance of height in *C. tamala*. *Cryptocarya* was found to rarely grow faster than 6 cm per month and found to be benefited by shade trees [11, 15]. A positive correlation between stem diameter and height was found [8, 11, 15].

4. Conclusion

The survival rate of *C. tamala* at Saldada CF at the first year was found to be 62%, 53% at Malayang CF, and 35% at Banaskhadi CF. The survival rate of Saldada CF was found to be highest among the three sites as Saldada CF was favoured by its aspects in comparison to Banaskhadi CF and Malayang CF. Total area of Saldada CF was at southwest landscape, while almost all areas of Banaskhadi CF were at the southern-eastern aspect, and mixed aspect was found at Malayang CF. Survival rate, growth performance at Saldada CF was found to be favoured by its aspect among all three sites, because of proper weeding survival rate and growth performance were also better than other site and also due to nearer user group.

Mortality of Banaskhadi CF was found to be more due to the small size of the plant, unfavourable site Cinnamomum tamala is favoured at southern-western aspect, but the plantation site of Banaskhadi CF is at the southern-eastern aspect because of which direct sunlight is faced by the seedling the whole day which increases the mortality rate. Banaskhadi CF plantation site was on the slate mine as the slate was extremely rocky with small and large stones, and also, the site was totally cleaned before plantation without any shade trees which causes an increase in mortality of the plant.

Soil pH required for *Cinnamomum* was acidic, but from the test, alkaline and neutral pH was observed. Soil OM required for the plant was high, but none of the sites had high OM content; also, Banaskhadi CF had low OM content as per the lab report. We can conclude that soil of all the three sites does not support *C. tamala* and its growth, and the lack of soil quality as required can be concluded as the prime cause of the failure of plantation in Banaskhadi CF, whereas a combination of multiple causes such as lack of weeding as improper soil quality can be the cause for Malayang CF.

Data Availability

The data used to write this report are primary data collected through a survey and prestructured questionnaire. All the raw and processed data are available from the corresponding author upon request.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

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